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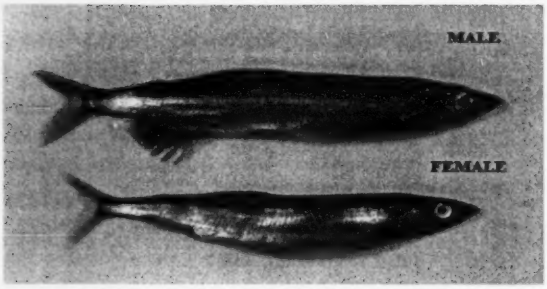
ASSESSMENT OF THE ESTUARY AND GULF OF ST. LAWRENCE (DIVISIONS 4RST) CAPELIN STOCK IN 2010



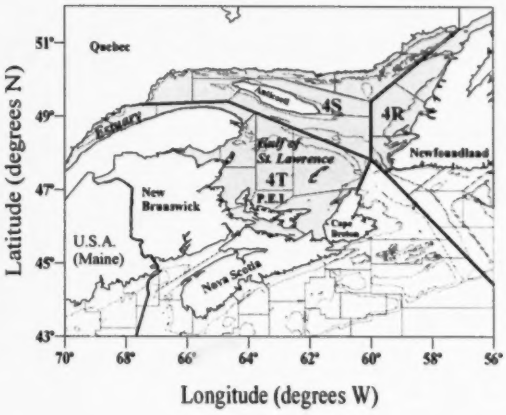


Figure 1. Map of NAFO Divisions 4RST (Estuary and Gulf of St. Lawrence). Divisions 4RST are identified by the coloured area.

Context

In the Estuary and Gulf of St. Lawrence, capelin has traditionally been used as fertilizer, bait or for its oil. Towards the end of the 1970s, the emergence of a Japanese market for roe-bearing females sparked a rapid growth of the fishery with catches that increased from approximately 700 t per year to nearly 10,000 t. In NAFO Divisions 4RST, most catches are made on the west coast of Newfoundland by a fleet of small and large purse seiners and by trap fishermen. Capelin are also caught using traps on Quebec's Lower North Shore and weirs in the St. Lawrence Estuary. In addition to recreational catches made on beaches during the spawning season, capelin are also a by-catch of the shrimp (Pandalus borealis) fishery and the groundfish and shrimp multidisciplinary surveys conducted annually in the Estuary and northern and southern Gulf of St. Lawrence.

Even though capelin population structures in the Estuary and Gulf of St. Lawrence are not clearly defined, the species is managed according to two distinct management units, NAFO Divisions 4R and 4ST (Figure 1). A Total Allowable Catch (TAC) of 11,195 t is applied to Division 4R compared with 1,805 t for all of Divisions 4ST. There is no abundance survey specifically directed on capelin. Consequently, it is impossible to calculate spawning biomass, fishing mortality and limit reference points, which would help define, based on the precautionary approach, a strategic framework for the fishery and a Total Allowable Catch (TAC).

The last capelin assessment in Divisions 4RST was conducted in 2008. The Fisheries and Aquaculture Management Branch requested science advice on this stock for the 2011, 2012 and 2013 fishing seasons. This document should meet, at least in part, their request as it provides a status update for this resource based on the information currently available.

Canada

SUMMARY

- Capelin landings in NAFO Divisions 4RST increased from 7,900 t in 2007 to a historic high of 12,080 t in 2009 and 10,806 t in 2010 (preliminary). Most of these landings were made with purse seines. An index measuring this fishery performance in 4R has increased since 2005 and the 2010 value is twice as high as the historic average.

- Since 2008, the purse seine quota (6,278 t) in Division 4R has almost always been reached compared to that of fixed gear (4,917 t). The allotted quota for all of Divisions 4ST (1,805 t) has been exceeded by 312 t on average (17%) per year since 2006.

- Capelin is a regular by-catch in the shrimp fishery. Based on observer data (5% coverage), 115 t of capelin would have been caught and discarded in 2010, for most of the Sept-Iles shrimp fishery management area. Since 1991, these catches have varied between 110 and 877 t. The discards are not recorded.

- On the west coast of Newfoundland, the length of capelin caught by purse seine declined in the early 1990s until 2001. It increased thereafter and the lengths measured since 2005 have been near the 1984-2009 period average. The length of capelin from the east coast of Newfoundland has declined more significantly, and since the mid-1990s, has been similar to that of the Gulf.

- Since 1990, the presence of capelin in the annual bottom trawl surveys has become more widespread in the southern Gulf of St. Lawrence (Division 4T). This could be explained by an increased presence of capelin near the bottom and/or by an increased abundance.

- According to the bottom trawl survey in the northern Gulf, the association between capelin and its main predators differs depending on the abundance and distribution of predators so that in recent years, this association has been linked more to Greenland halibut and American plaice rather than redfish and Atlantic cod.

- Any TAC increase in 4RST should be made cautiously due to capelin's prominent role as forage species in the marine ecosystem (less than 10% as a total over the next three years).

- The purse seine fishing effort within each Division should be more dispersed.

INTRODUCTION

Species Biology

Capelin (*Mallotus villosus*) is a small marine fish species largely distributed in the oceans of the northern hemisphere. In the northeast Atlantic, capelin occur in waters near Russia (Barents Sea), Norway, Iceland, and Greenland. In the northwest Atlantic, it is found along the coasts of Labrador and Newfoundland, on the Grand Banks and in the Estuary and Gulf of St. Lawrence. Further south, capelin are also found in the eastern portion of the Scotian Shelf and

occasionally, in the Bay of Fundy. In the Pacific, the species occurs along the coasts of Alaska and British Columbia, and in Asia, along the coasts of Japan, Korea, and Russia.

Capelin are part of the Osmeridae family and are olive in colour and have an elongated body. During the spawning period, there is a pronounced sexual dimorphism, males can be distinguished from females by their larger fins and by the occurrence of two pairs of spawning carina (elongated scales), one dorsal and the other ventral. Spawning is preceded by intense migration towards the coast and occurs inter-tidally on beaches and in deeper waters. In the first case, capelin literally "roll" on the sandy or fine gravel beaches. Spawning essentially occurs at water temperatures of 6-10°C and is more predominant at night. The eggs, which are reddish in colour and approximately 1 mm in diameter, attach to the substrate. The incubation period varies according to ambient temperature, lasting for approximately 15 days at 10°C. Upon hatching, larvae quickly adopt a planktonic existence and remain near the surface until the arrival of winter. The most significant growth period occurs during the first year. Males are longer than females, with maximum lengths rarely above 210 mm. Capelin can spawn at 2 years of age, and nearly 100% of males die following reproduction.

Capelin represent a very significant link in the food chain as they allow the transfer of energy from primary and secondary producers to higher trophic levels. In the mid-1980s, the annual capelin consumption by its main predators was approximately one million tons. In the early 2000s, despite a sharp drop in cod (*Gadus morhua*) and redfish (*Sebaste* spp.) abundance, nearly 400,000 t of capelin were still consumed by predators (C. Savenkoff, DFO, Mont-Joli, pers. comm.), making this small fish the principal forage species of the northern Gulf of St. Lawrence marine ecosystem over the last 20 years.

ANALYSIS

Commercial Fishery

Description of fishing activities

Purse seines, traps and weirs are the main commercial capelin fishing gear used in the Estuary and Gulf of St. Lawrence. Fishing seasons are generally short and correspond to the pre-spawning period for the purse seine fishery and to the spawning period for the trap and weir fisheries. In the case of the purse seine and trap, the fishery mostly targets mature females for the Japanese roe market. The emergence of this market in the late 1970s is responsible for the sharp increase in landings, up from an average of 700 t/year between 1960 and 1976 to approximately 10,000 t in 1978 and 1979, but also in 1992, 1998 and 2005 (Figure 2). Landings exceeding 10,000 t were even made in 2006 and since 2008.

Most capelin catches in the Estuary and Gulf of St. Lawrence occur on the west coast of Newfoundland, i.e. in NAFO (Northwest Atlantic Fisheries Organization) Division 4R (Figure 1). In Divisions 4R and 4S, the most intensive fishing usually occurs in June and July. In Division 4T (Estuary), the fishing season can begin as early as April, but most catches occur in May and June.

In recent years, a purse seine fishery has developed in unit area 4Tn. In 2009 and 2010, capelin catches with this gear totalled 1,367 t and 1,193 t respectively.

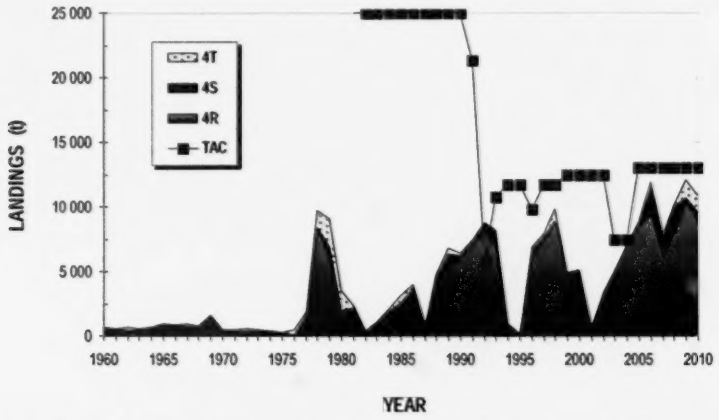


Figure 2. Capelin landings and TAC (t) for NAFO Divisions 4RST between 1960 and 2010. Since 2005, the TAC has been divided as follows: 11,195 t for Division 4R and 1,805 t for Divisions 4ST.

The 2008, 2009 and 2010 fishing seasons

Landings exceeding 10,000 t have been made in Divisions 4RST since 2008 (Table 1). During these three years, landings in Division 4R totalled 7,846 t, 10,147 t and 8,753 t, which represent 70-91% of the TAC. A significant increase in landings has been measured in Divisions 4S and 4T (4Tn) so that the common TAC in these two Divisions was exceeded by 420 t (23%), 128 t (7%) and 248 t (14%) in 2008, 2009 and 2010, with an average of 312 t (17%) since 2006. The two main fishing gears remained the purse seine and trap, followed by the "*Tuck ring*" seine (Table 1, Figure 3).

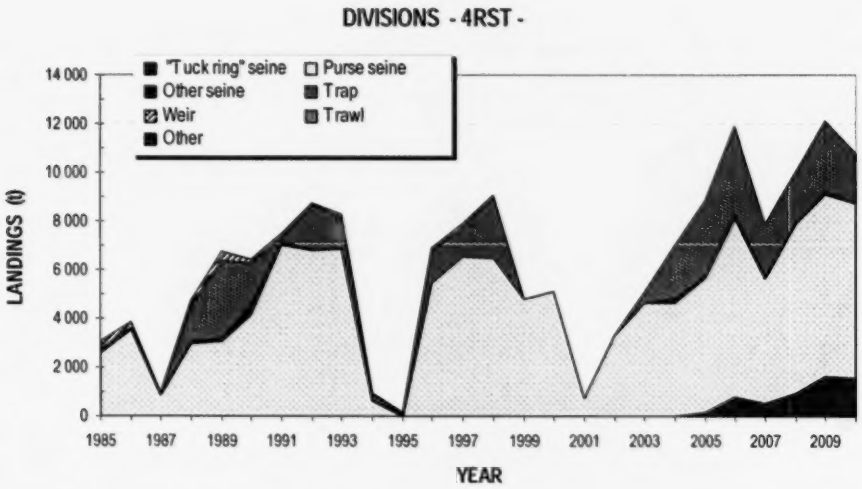


Figure 3. Estuary and Gulf of St. Lawrence capelin landings (t) by fishing gear for the 1985-2010 period.

On the west coast of Newfoundland, most of the 2008 landings were made in unit area 4Rd (St. George's Bay) with a total of 4,083 t compared to 4Rc and 4Rb in 2009 and 2010, with respective landings of 4,116 t and 4,595 t (Table 2).

Table 1. Estuary and Gulf of St. Lawrence capelin landings (t) by NAFO Division and by fishing gear for the 1985-2010 period.

DIVISION / GEAR	AVERAGE		YEAR											AVERAGE
	1985-1989	1990-1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010*	2000-2009
4R	3 369	5 563	5 129	741	3 295	5 032	6 975	8 522	9 326	6 085	7 846	10 147	8 753	6 310
TAC 4R			*10 700*	*10 700*	*10 700*	*6 420*	*6 420*	*11 195*	*11 195*	*11 195*	*11 195*	*11 195*	*11 195*	
%	17	63	*48*	*7*	*31*	*78*	*109*	*76*	*83*	*54*	*70*	*91*	*78*	65
4S	241	350	0	0	77	0	0	305	2 039	1 344	2 126	527	795	642
4T	306	237	0	0	20	0	0	34	518	471	99	1 405	1 258	255
Total	547	588	0	0	97	0	0	339	2 557	1 815	2 225	1 933	2 053	897
TAC 4ST			*1 725*	*1 725*	*1 725*	*1 035*	*1 035*	*1 805*	*1 805*	*1 805*	*1 805*	*1 805*	*1 805*	
%	11	33	*0*	*0*	*6*	*0*	*0*	*19*	*142*	*101*	*123*	*107*	*114*	50
4RST														
"*Tuck ring*" seine	0	0	0	0	0	0	0	182	788	519	967	1 657	1 586	411
Purse seine	2 586	4 872	5 129	741	3 295	4 654	4 639	5 485	7 335	5 097	6 916	7 445	7 182	5 074
Other seine**	88	59	0	0	0	0	188	116	193	133	54	141	0	82
Trap	960	1 040	1	0	7	379	2 148	3 078	3 567	2 151	2 135	2 837	2 058	1 630
Weir	243	91	0	0	0	0	0	0	0	0	0	0	0	0
Trawl	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Other	39	89	0	0	87	0	0	0	0	0	0	0	0	9
TOTAL	3 916	6 151	5 129	741	3 392	5 032	6 975	8 861	11 883	7 900	10 071	12 080	10 806	7 207

* Préliminary; ** Not specified

Table 2. West coast of Newfoundland (4R) capelin landings (t) by NAFO unit area for the 1985-2010 period.

UNIT AREA	AVERAGE		YEAR											AVERAGE
	1985-1989	1990-1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010*	2000-2009
4Ra	1 163	699	0	0	115	513	3 965	4 946	5 917	5 315	883	2 570	2 517	2 422
4Rb	41	1 261	356	0	856	1 070	765	942	9	6	188	2 929	4 595	712
4Rc	439	2 812	4 773	605	2 323	3 450	2 185	2 289	2 644	691	2 692	4 116	1 466	2 577
4Rd	52	527	0	136	0	0	61	346	756	73	4 083	531	176	599
NK**	1 673	264	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3 369	5 563	5 129	741	3 295	5 032	6 975	8 522	9 326	6 085	7 846	10 147	8 753	

* Preliminary; ** Not specified

Location of catches and purse seine fishery performance

Over the last three years, purse seine fishery activities were concentrated in three different locations. In 2009 and 2010, they were conducted mostly in Port-au-Port Bay (4Rc) and near Port au Choix (4Rb) (Figure 4). However, in 2008, over 50% (4,083 t) of the catches were made at a single point located on the east coast of St. George's Bay (4Rd).

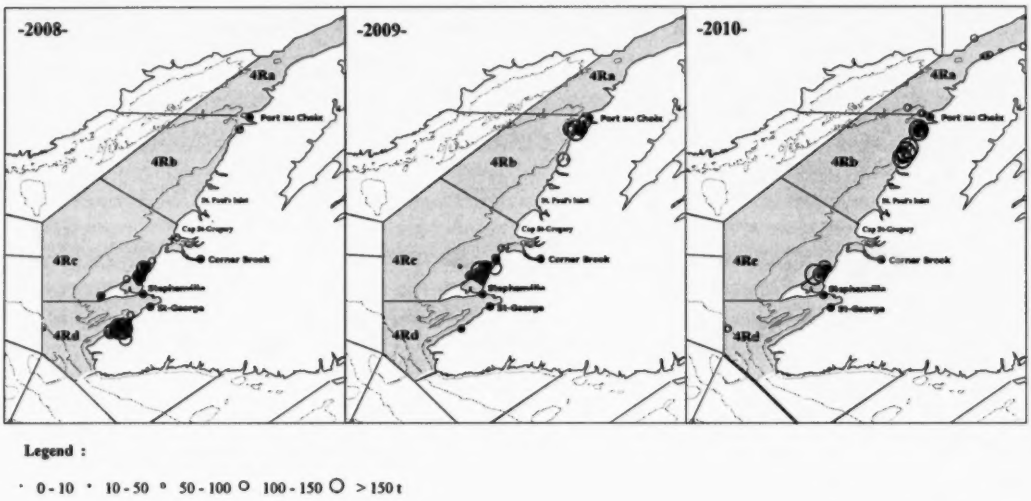


Figure 4. Locations of capelin catches (t) made by the purse seine fishery in NAFO Division 4R between 2008 and 2010.

The purse seine fishery performance in Division 4R is measured using a catch-per-unit-effort (t/day) standardized index. This index has been increasing since 2005, and the values measured in 2009 and 2010 are the highest of the series (Figure 5). The average index measured for the 1986-2009 period is 24 t per fishing day. The upper bound of this average (mean + 0.5 x standard deviation) was exceeded in 1990, 1991, 2002 and since 2006.

Capelin catches using the purse seine were made in the southern Gulf of St. Lawrence in 1993, 1994, 1999, 2006 and since 2008 (Figure 5). With the exception of 2006 and 2010, the annual performances from this fishery have been less than those measured on the west coast of Newfoundland. The highest indices (2006, 2009 and 2010) also show more variability.

Shrimp fishery by-catches

Capelin are a regular by-catch in the shrimp fishery. In the spring, and in areas such as the Esquiman Channel or west of Anticosti, the number of capelin caught by shrimpers can be significant. Some fishermen avoid some sectors during certain periods to avoid catching too many capelin. According to observers' data, capelin by-catches by shrimpers decreased from 877 t in 1993 to a low of 113 t in 1996 (Figure 6). This drop is a result of the introduction of the Nordmore grate. Capelin catches have since fluctuated with values ranging between 110 t (2007) and 536 t (2009). Most of these catches were made in the Sept-Iles shrimp fishery management area, except for 1993, 1996, 2001, 2002, 2008 and 2009, when the dominant areas were the Esquiman region or Anticosti (Figure 6).

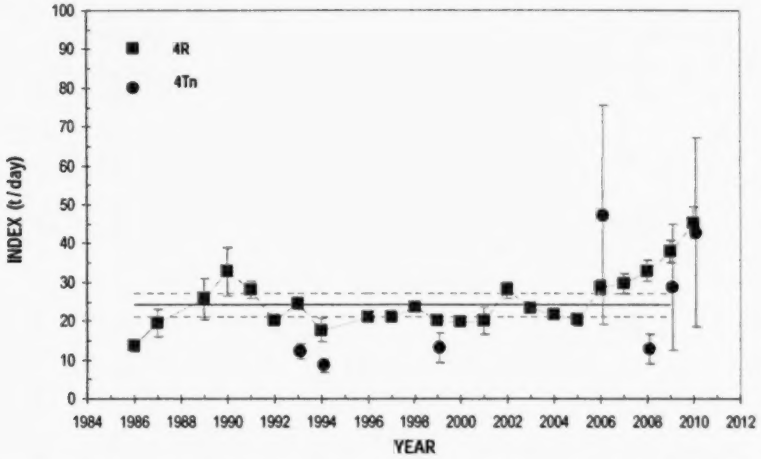


Figure 5. Purse seine fishery performance (t/day) in NAFO Division 4R (west coast of Newfoundland) and unit area 4Tn as measured by a catch-per-unit-effort standardized index (vertical bars represent standard errors). Horizontal lines represent the mean for the 1986-2009 period ± 0.5 x standard deviation for Division 4R.

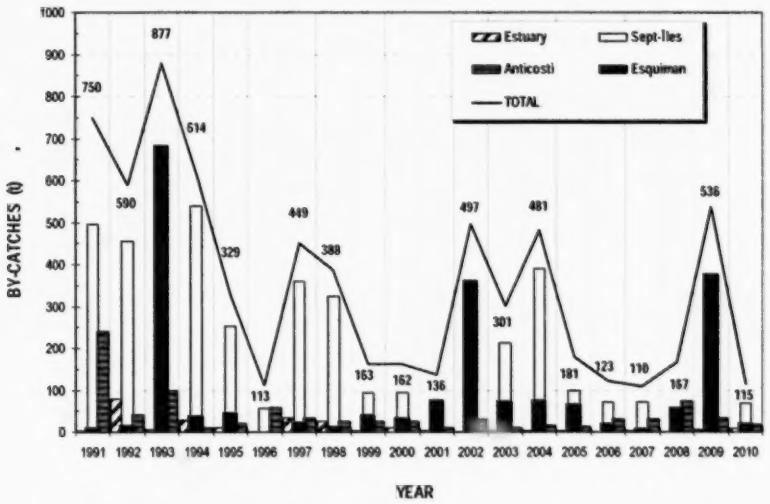


Figure 6. Annual capelin by-catch estimates (t) from the commercial shrimp fishery since 1991 (source of data: L. Savard, DFO, Mont-Joli, pers. comm.; Biorex and Seawatch observer program). Shrimp fishery management areas are indicated.

Temporal pattern of the fishery

Purse seine fishing seasons in unit area 4Rc have gradually occurred later between 1985 and 1995 (Figure 7A). A certain consistency has been observed since, except for 1998, 2005 and 2006, when fishing seasons occurred earlier.

The trap fishing seasons on Quebec's Lower North Shore were far more variable (Figure 7B). This fishery also occurs after the purse seine fishery in the southern Gulf.

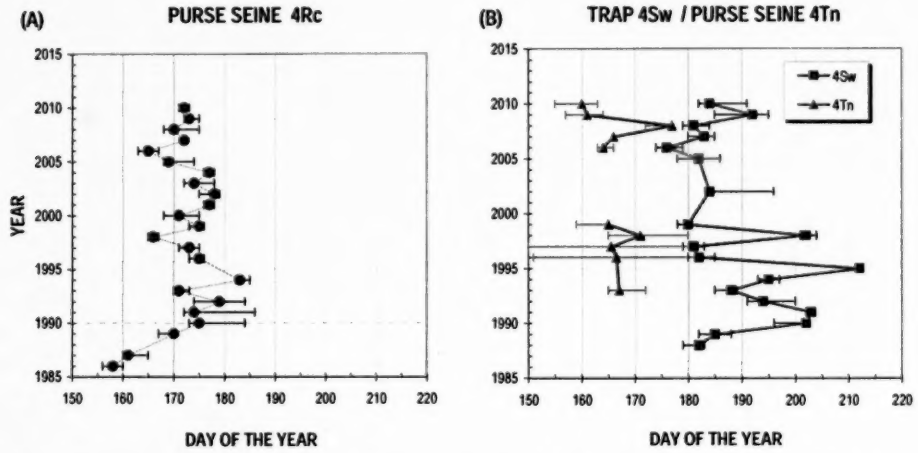


Figure 7. Temporal patterns of the capelin purse seine fishery in unit area 4Rc (A) (west coast of Newfoundland) and the trap and purse seine fisheries in unit areas 4Sw (Quebec's Lower North Shore) and 4Tn (southern Gulf). The symbols represent the median landing dates and the bars, the dates by which 25% and 75% of the landings were made.

Description of catches

Mean lengths for both male and female capelin decreased along the west coast of Newfoundland between 1986 and 1993 (Figures 8A and 8B). As the fishing effort is dependent upon fish size, the fishery was cut short in 1994, and almost completely closed in 1995. Capelin size stabilized between 1996 and 1998, before decreasing again in 1999. Lengths increased between 1999 and 2003 and have remained stable since. In 2010, mean length was 146 mm for females and 165 mm for males.

Mean lengths for capelin on the east coast of Newfoundland (Divisions 3K and 3L) show the same annual variations as on the west coast (Figures 8A and 8B). However, sizes were larger during the 1980s.

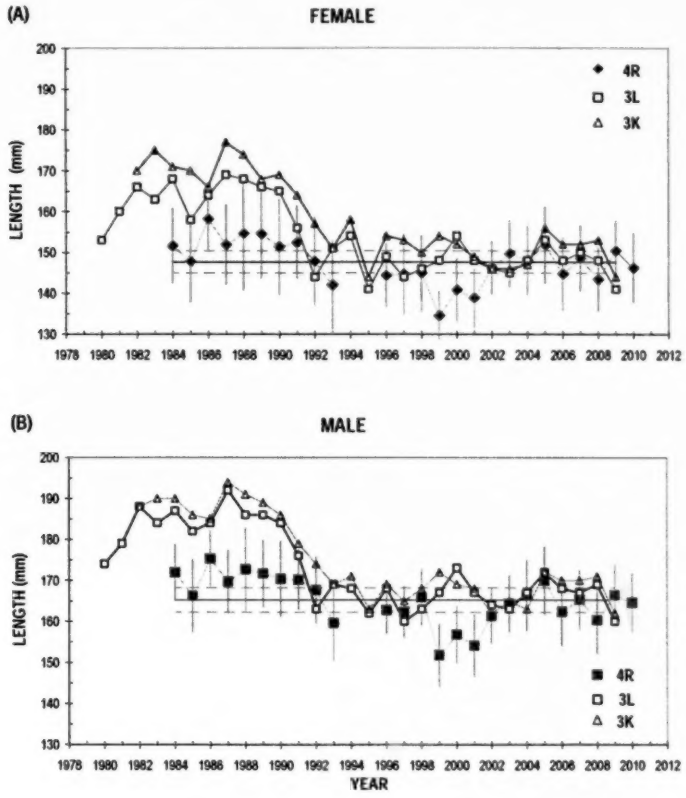


Figure 8. Mean length (mm) of female (A) and male (B) capelin caught with purse seines in NAFO Division 4R since 1984. Mean lengths for the east coast of Newfoundland (Divisions 3L, 3K) are also presented (Dr. B. Nakashima, DFO, St. John's, pers. comm.). The horizontal lines indicate the mean for the 1984-2009 period ± 0.5 x standard deviation.

Fluctuations in capelin size are also observed in the annual length frequencies (Figure 9). In most years, the length frequencies consist of one main mode as a result of overlapping lengths among various age groups.

In 2010, the size of capelin caught with purse seines on the west coast of Newfoundland (Division 4R) was higher that the capelin caught with traps on Quebec's Lower North Shore (unit area 4Sw) (Figures 10A and 10B). The smallest sizes recorded were from samples from the purse seine fishery in the southern Gulf (unit area 4Tn).

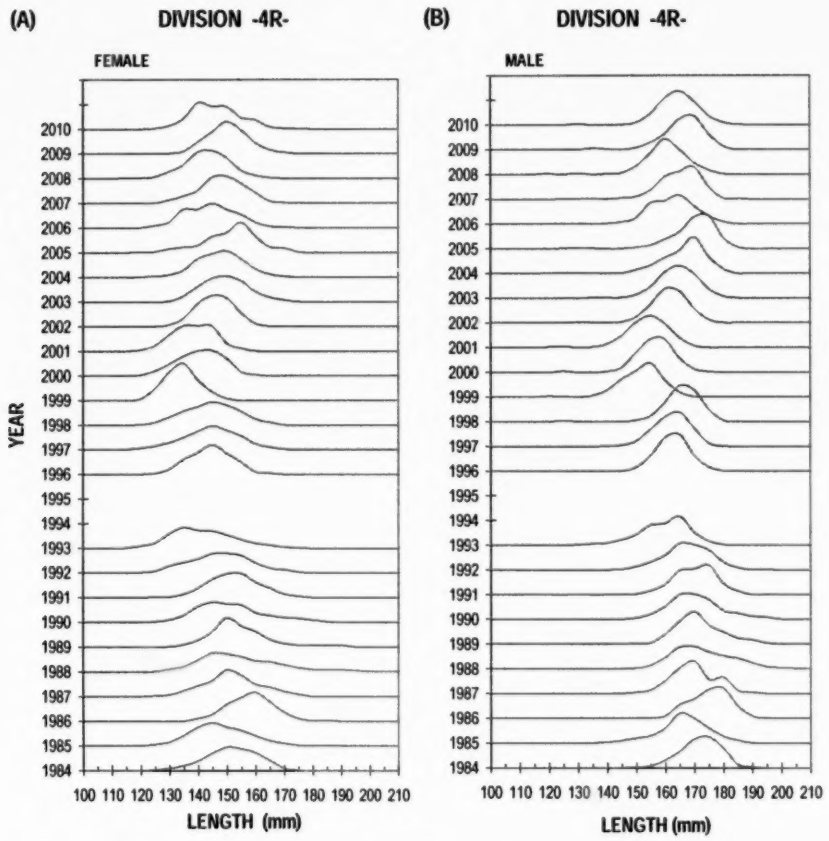


Figure 9. Length (mm) frequencies (%) of female (A) and male (B) capelin caught with purse seines in NAFO Division 4R between 1984 and 2010.

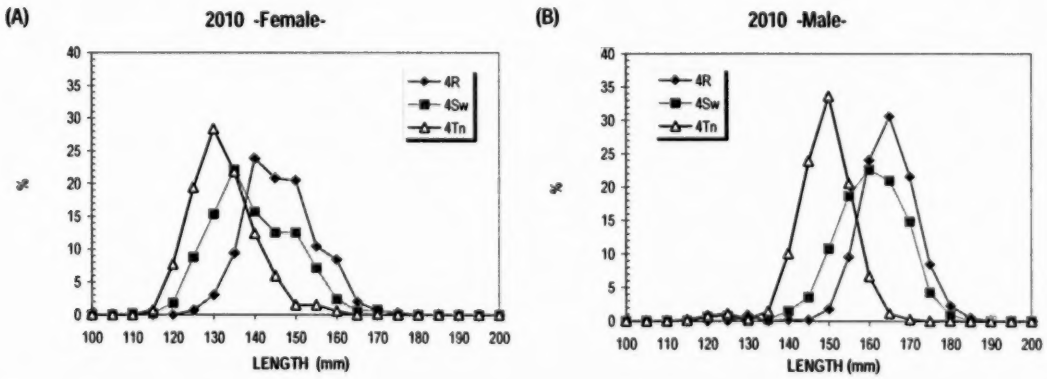


Figure 10. Length (mm) frequencies (%) of female (A) and male (B) capelin measured in 2010 for samples from the purse seine fishery in Division 4R (west coast of Newfoundland) and unit area 4Tn, and from the trap fishery in unit area 4Sw (Quebec's Lower North Shore).

Resource Status

Catch distribution and dispersion index

Capelin are a regular catch in groundfish and shrimp multidisciplinary surveys conducted in the Estuary and the northern and southern Gulf of St. Lawrence. A dispersion index (not an abundance index) is calculated by indicator kriging based on the presence or absence of capelin in these surveys. The dispersion index indicates a clear upward trend since 1990 in the Estuary and Gulf of St. Lawrence (Figure 11). Over the years, significant fluctuations have been observed on the west coast of Newfoundland (Division 4R) including a sharp drop between 2003 and 2006 (Figure 12). This decrease was followed by an increase and the values measured between 2008 and 2010 exceeded the 1990-2009 period average. Annual variations of the dispersion index can easily be observed from reviewing the surface probability maps (Figure 13).

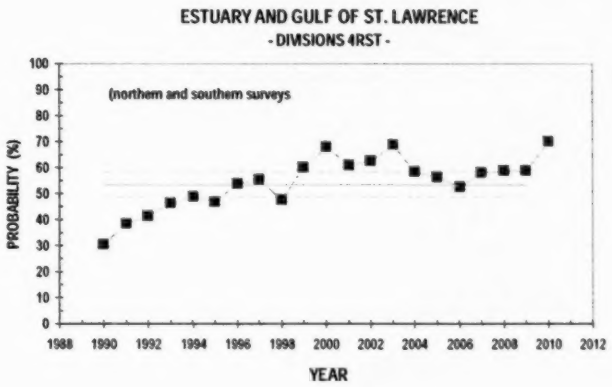


Figure 11. Capelin dispersion index (%) for NAFO Divisions 4RST covered by the groundfish and shrimp multidisciplinary surveys in the Estuary and northern and southern Gulf of St. Lawrence. The horizontal lines indicate the 1990-2009 period average ± 0.5 x standard deviation.

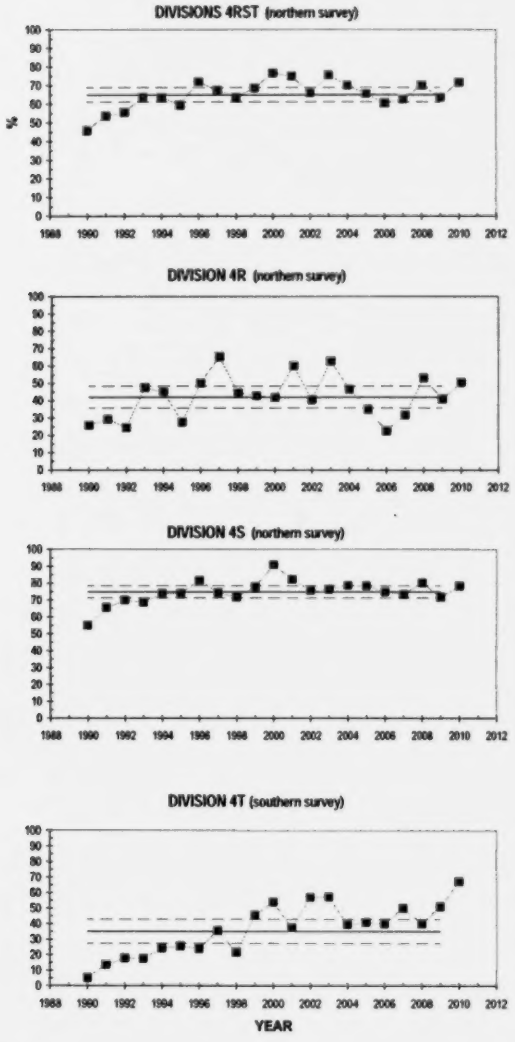


Figure 12. Capelin dispersion index (%) for the NAFO Divisions covered by the groundfish and shrimp multidisciplinary surveys in the Estuary and northern and southern Gulf of St. Lawrence. The horizontal lines indicate the 1990-2009 period average ± 0.5 x standard deviation.

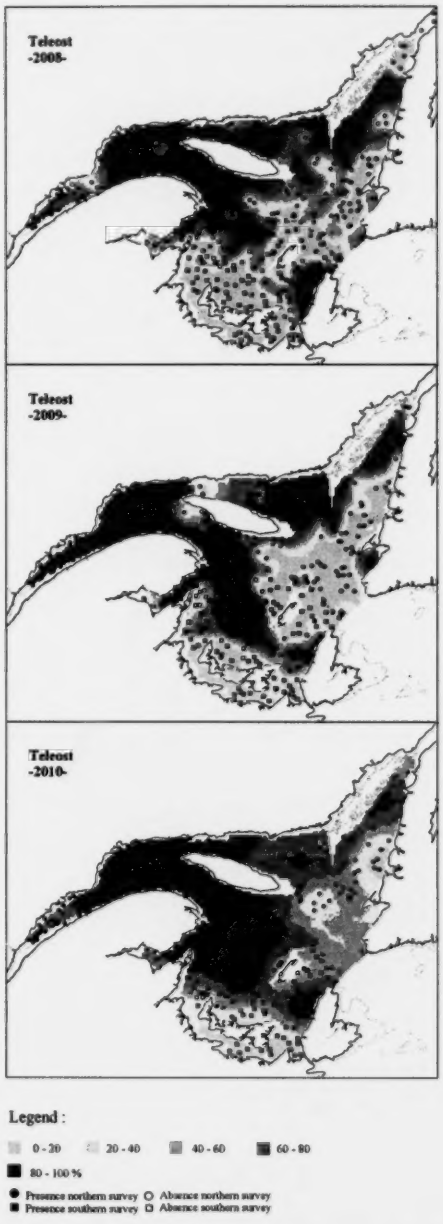


Figure 13. Surface probability (%) maps of capelin occurrence in the Estuary and Gulf of St. Lawrence as measured in 2008, 2009 and 2010 by the groundfish and shrimp multidisciplinary surveys. Station location, capelin occurrence and the 100 m isobath are indicated.

Capelin in the southern Gulf of St. Lawrence

Capelin catches from the groundfish multidisciplinary survey in the southern Gulf of St. Lawrence have increased significantly since 1990 (almost nil prior) (Figure 14). The first catches were made offshore Gaspé and gradually extended southward in following years. In 2010, almost all tows yielded capelin.

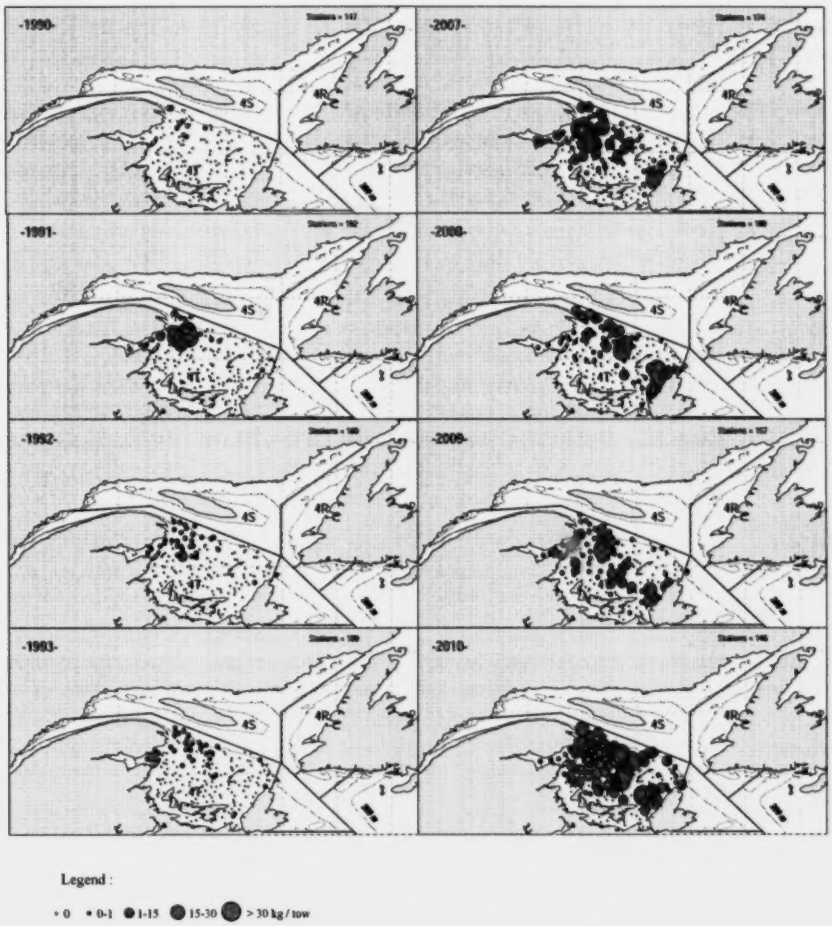


Figure 14. Weight (kg) per tow by the groundfish multidisciplinary survey in the southern Gulf of St. Lawrence for the 1990-1993 and 2007-2010 periods (T. Surette, DFO, Moncton, pers. comm.).

This increase could be explained not by an actual increase in the abundance of capelin, but by an increased presence of this species in the suprabenthic habitat abandoned by the decreasing populations of groundfish.

Sources of uncertainty

The primary source of uncertainty is the absence of information regarding capelin abundance in the Estuary and Gulf of St. Lawrence. There is also a lack of information on the number, the

location, and size of spawning grounds and stock structure. Furthermore, there is very little information concerning the role of certain environmental variables on annual migration patterns.

Ecosystem

Marine ecosystem models indicate that capelin was the primary prey for the northern Gulf of St. Lawrence ecosystem and represented on average 50% of the consumed matter in the ecosystem between the mid-1980s and mid-2000s. Therefore, the main cause of capelin mortality is predation (Figure 15), mostly by large cod and redfish during the mid-1980s, by cetaceans, harp seals (*Phoca groenlandica*) and Greenland halibut (*Reinhardtius hippoglossoides*) during the mid-1990s and the early 2000s, and by redfish and capelin during the mid-2000s (Figure 16) (C. Savenkoff, DFO, Mont-Joli, pers. comm.). Fishing mortality does not appear to have a noticeable effect on the population(s) at current landing levels, although it is currently impossible to evaluate.

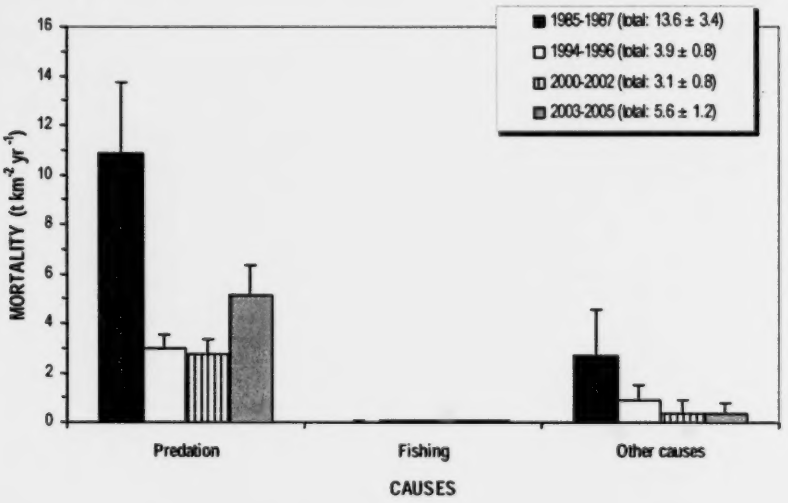


Figure 15. Main causes of capelin mortality (t km^{-2} yr^{-1}) according to different northern Gulf of St. Lawrence marine ecosystem models (Divisions 4RS) from the mid-1980s to the mid-2000s.

Over the years, capelin are among the main species that have characterized catches in the groundfish multidisciplinary surveys in the northern Gulf of St. Lawrence (Figure 17). Capelin catches in these surveys are associated with those by their main predators according to their abundance and distribution so that in recent years, this association has further been connected to Greenland halibut and American plaice (*Hippoglossoides platessoides*) than redfish and Atlantic cod.

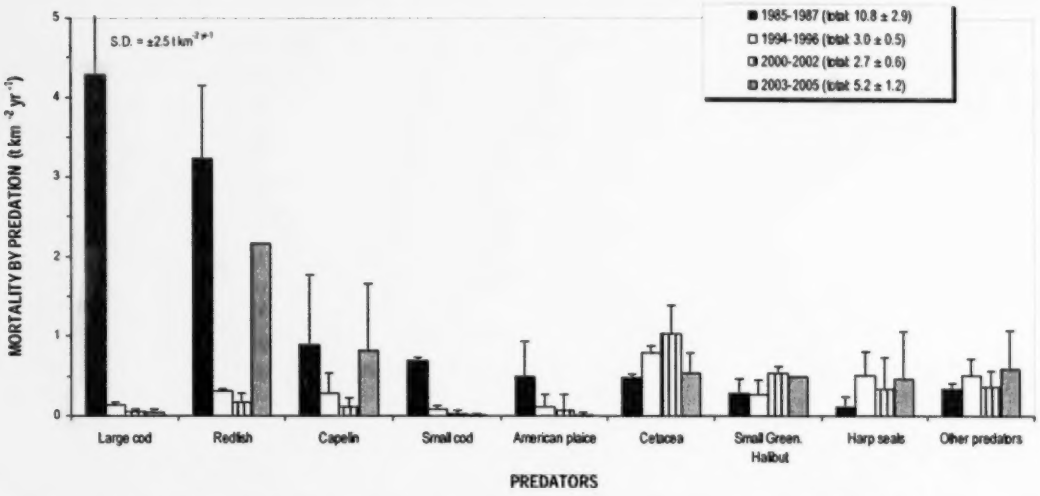


Figure 16. Detailed mortality by predation according to different northern Gulf of St. Lawrence marine ecosystem models (Divisions 4RS) from the mid-1980s to the mid-2000s.

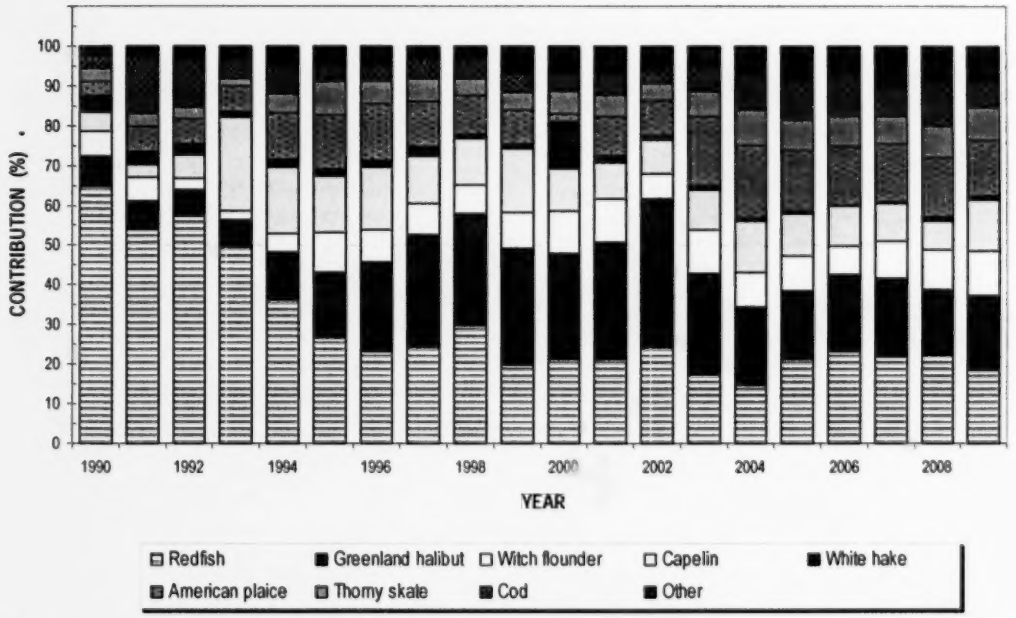


Figure 17. Contribution (%) of capelin catches and its main predators to groups of species that characterized the groundfish multidisciplinary surveys conducted in the northern Gulf of St. Lawrence between 1990 and 2009.

CONCLUSION AND ADVICE

It is currently impossible to estimate the impact of a significant increase in landings on the capelin population(s) and the rest of the ecosystem because variations in capelin abundance are first and foremost the result of natural factors. As capelin has a short lifespan, its abundance can be subject to large changes as a population consists of only a few age groups. To satisfy market demand, fishing effort is strongly correlated to the size of female capelin. The industry has a greater interest in regions where environmental conditions are more favourable to capelin growth.

Although the commercial fishery may harvest a very small proportion of the total biomass, any TAC increase should be made cautiously due to capelin's prominent role as a forage species in the marine ecosystem (less than 10% as a total over the next three years). Fishing effort should also be dispersed all along the coast and not concentrated in localized areas.

SOURCES OF INFORMATION

This Science Advisory Report is from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, regional advisory meeting of February 17, 2011 on Assessment of Estuary and Gulf of St. Lawrence (divisions 4RST) capelin stock. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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